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Journal of the Mechanics and Physics of Solids
54 (2006) 1147–1185
JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS
www.elsevier.com/locate/jmps

Anisotropic model for granulated sea ice dynamics

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Received 13 July 2005; received in revised form 15 December 2005; accepted 30 December 2005

Abstract

A continuum model describing sea ice as a layer of granulated thick ice, consisting of many rigid, brittle floes, intersected by long and narrow regions of thinner ice, known as leads, is developed. We consider the evolution of mesoscale leads, formed under extension, whose lengths span many floes, so that the surrounding ice is treated as a granular plastic. The leads are sufficiently small with respect to basin scales of sea ice deformation that they may be modelled using a continuum approach. The model includes evolution equations for the orientational distribution of leads, their thickness and width expressed through second-rank tensors and terms requiring closures. The closing assumptions are constructed for the case of negligibly small lead ice thickness and the canonical deformation types of pure and simple shear, pure divergence and pure convergence. We present a new continuum-scale sea ice rheology that depends upon the isotropic, material rheology of sea ice, the orientational distribution of lead properties and the thick ice thickness. A new model of lead and thick ice interaction is presented that successfully describes a number of effects: (i) because of its brittle nature, thick ice does not thin under extension and (ii) the consideration of the thick sea ice as a granular material determines finite lead opening under pure shear, when granular dilation is unimportant.

Keywords: Granulated; Anisotropic; Plastic; Sea ice

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doi:10.1016/j.jmps.2005.12.006